AGREEMENT #12167 FOR ENGINEERING SERVICES

This AGREEMENT is entered into by and between Lake County (County) and Pure Technologies US, Inc. 8920 State Route 108 Suite D, Columbia, MD 21045 (hereafter "Engineer").

RECITALS

WHEREAS, Lake County is seeking an Engineer to provide Engineering services for

> PW#2012.027 Northwest Force Main Assessment as described in Attachment A; and

WHEREAS A Statement of Interest # 12046 for Professional Civil Engineering Services was published and sealed proposals were received on February 29, 2012.

WHEREAS, the Engineer is a professional provider of Engineering services; and

NOW, THEREFORE, Lake County and the Engineer AGREE AS FOLLOWS:

SECTION 1. AGREEMENT DOCUMENTS
This AGREEMENT constitutes the entire agreement between the County and the Engineer.

SECTION 2. SCOPE OF SERVICES
The Engineer shall provide engineering services described in Attachment A dated June 25, 2102

SECTION 3. DURATION
The works shall be completed within __120__days after execution of this Agreement.

SECTION 4. INDEMNIFICATION
The Engineer agrees to indemnify, save harmless and defend the County, their agents, servants, and employees, and each of them against and hold it and them harmless from any and all lawsuits, claims, demands, liabilities, losses and expenses, including court costs and attorney's fees, for or on account of any injury to any person, or any death at any time resulting from such injury, or any damage to property, which may arise or which may be alleged to have arisen out of Engineer's negligent acts in connection with the services covered by this Agreement. The foregoing indemnity shall apply except if such injury, death or damage is caused directly by the willful and wanton conduct of the County, their agents, servants, or employees or any other person indemnified hereunder.

SECTION 5. INSURANCE
The Engineer must obtain, for the Contract term and any extension of it, insurance issued by a company or companies qualified to do business in the State of Illinois and provide

the County with evidence of insurance. Insurance in the following types and amounts is necessary:

- **Worker's Compensation Insurance** covering all liability of the Engineer arising under the Worker's Compensation Act and Worker's Occupational Disease Act at statutory limits.
- **Professional Liability** to include, but not be limited to, coverage for Errors and Omissions to respond to claims for loss there from.
    - **General Aggregate Limit $3,000,000**
    - **Each Occurrence Limit $1,000,000**
- **Automobile Liability:**
    - **Bodily Injury, Property Damage (Each Occurrence Limit) $1,000,000**

Engineer agrees that with respect to the above required Automobile Liability insurance, Lake County shall:

- Be named as additional insured by endorsement to the extent of the negligence of the Engineer;
- Be provided with thirty (30) days notice, in writing, of cancellation of material change;
- Be provided with Certificates of Insurance evidencing the above required insurance, prior to commencement of this Contract and thereafter with certificates evidencing renewals or replacements of said policies of insurance at least fifteen (15) days prior to the expiration of cancellation of any such policies. Forward Notices and Certificates of Insurance to: Lake County Central Services, 18 N. County St, Waukegan, IL 60085-4350.

SECTION 6. AGREEMENT PRICE
Lake County will pay to the Engineer the amount not to exceed $167,500.

SECTION 7. INVOICES & PAYMENT
Invoices may be submitted for work performed on a monthly basis based upon the percent of work completed in the amount not-to-exceed in Section 6. Submit invoice(s) detailing the services provided. Payments shall be made in accordance with the Local Government Prompt Payment Act.

Engineer will address Invoices to:
Lake County Department of Public Works
650 Winchester Road
Libertyville, IL 60048-1391
Attn: Peter Kolb

County will make Payments to:
Quality Power Solutions, LLC
5812 Manufacturers Dr,
Madison WI 53704

SECTION 8. STATEMENT OF OWNERSHIP
The drawings, specifications and other documents prepared by the Engineer for this Project are the property of the County, and Engineer may not use the drawings and specifications for any purpose not relating to the Project without the County's consent, except for the Engineer's services related to this Project. All such documents shall be the property of the County who may use them without Engineer's permission for any current or future Lake County project; provided, however, any use except for the specific purpose intended by this Agreement will be at the County's sole risk and without liability or legal exposure to the Engineer.

The Engineer shall retain its copyright and ownership rights in its design, drawing details, specifications, data bases, computer software, and other proprietary property. Intellectual property developed, utilized, or modified in the performance of the services shall remain the property of the Engineer.

SECTION 9. TERMINATION
The County reserves the right to terminate this Agreement, or any part of this Agreement, upon thirty(30) days written notice. In case of such termination, the Engineer shall be entitled to receive payment from the County for work completed to date in accordance with terms and conditions of this Agreement. In the event that this Agreement is terminated due to Engineer's default, the County shall be entitled to contract for consulting services elsewhere and charge the Engineer with any or all losses incurred, including attorney's fees and expenses.

SECTION 10. JURISDICTION, VENUE, CHOICE OF LAW
This Agreement shall be governed by and construed according to the laws of the State of Illinois. Jurisdiction and venue shall be exclusively found in the 19th Judicial Circuit Court, State of Illinois.

SECTION 11. INDEPENDENT CONTRACTOR
The Engineer is an independent contractor and no employee or agent of the Engineer shall be deemed for any reason to be an employee or agent of the County.

SECTION 12. WARRANTS
The Engineer represents and warrants to the County that none of the work included in this contract will in any way infringe upon the property rights of others. The Engineer shall defend all suits or claims for Engineer's infringement of any patent, copyright or trademark rights and shall hold the County harmless from loss on account thereof.

SECTION 13. ASSIGNMENT
Neither the Engineer nor the County shall assign any duties of performance under this Agreement without the express prior written consent of the other.

SECTION 14. MODIFICATION
This Agreement may be amended or supplemented only by an instrument in writing executed by the party against whom enforcement is sought.

SECTION 15. DISPUTE RESOLUTION
All issues, claims, or disputes arising out of this Agreement shall be resolved in accordance with the Appeals and Remedies Provisions in Article 9 of the Lake County Purchasing Ordinance.

SECTION 16. NO IMPLIED WAIVERS
The failure of either party at any time to require performance by the other party of any provision of this Agreement shall not affect in any way the full right to require such performance at any time thereafter. Nor shall the waiver by either party of a breach of any provision of this Agreement be taken or held to be a waiver of the provision itself.

SECTION 17. SEVERABILITY
If any part of this Agreement shall be held to be invalid for any reason, the remainder of this Agreement shall be valid to the fullest extent permitted by law.

SECTION 18. CHANGE IN STATUS
The Engineer shall notify the County promptly of any change in its status resulting from any of the following: (a) vendor is acquired by another party; (b) vendor becomes insolvent; (c) vendor, voluntary or by operation law, becomes subject to the provisions of any chapter of the Bankruptcy Act; (d) vendor ceases to conduct its operations in normal course of business. The County shall have the option to terminate this Agreement with the Engineer immediately on written notice based on any such change in status.

SECTION 19. DELIVERABLES
The Engineer shall provide deliverables as identified in Attachment A.

IN WITNESS HEREOF, the undersigned have caused this Agreement to be executed in their respective names on the dates hereinafter enumerated.

Lake County:	Pure Technologies US, Inc.
_____	_____
RuthAnne Hall Purchasing Agent	
Date:_____	Date:_____

Attachment A
Scope of Services

Professional Engineering Services
Pure Technologies
Force Main Assessment Program
Internal Inspection
5,500 Fee of 30-Inch PCCP Force Main
June 25, 2012

PROJECT SCOPE

Professional Engineering Services
Force Main Assessment Program
Internal Inspection
5,500 Feet of 30-Inch PCCP Force Main

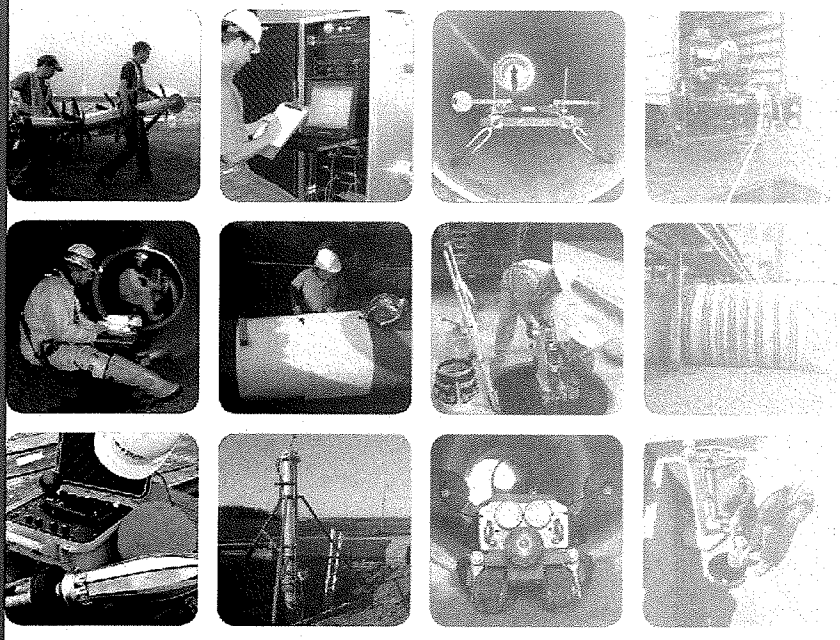
Prepared for

LakeCounty

State of Illinois
Lake County Public Works Department

By Pure Technologies US Inc.

June 25, 2012



pure TECHNOLOGIES

Pure Technologies US Inc. ▪ 8920 State Route 108, Suite D ▪ Columbia, MD 21045 ▪ Phone: 443-766-7873 ▪ Fax: 443-766-7877

www.puretechltd.com

June 25, 2012

Lake County Public Works Department
Mr. Art Malm, Principal Civil Engineer
650 Winchester Road
Libertyville, Illinois, 60048

RE: Condition Assessment Proposal for the 5,500 Feet of 30-Inch PCCP South Force Main

Dear Mr. Malm,

Pure Technologies is pleased to submit this Proposal for the Condition Assessment of the 5,500 Feet of 30-Inch PCCP South Force Main. Pure Technologies and its subsidiaries are recognized leaders in the field of pipe assessment with experience in the successful execution of force main inspection and condition assessment throughout North America. We are committed to providing the Lake County Public Works with high quality assessment services in an efficient, cost effective manner.

Upon your review of our Proposal, if you have any questions regarding any of the material contained herein, please do not hesitate to contact me.

Sincerely,

Pure Technologies US Inc.

Michael J. Livermore
Midwest Regional Manager

Pure Technologies U.S., Inc.
8920 State Route 108, Suite D
Columbia, Maryland 21045
Office (217) 590-2645
Cell (217) 419-4729
Email Michael.Livermore@puretechltd.com

Project Scope

The comprehensive condition assessment and management of wastewater force mains has historically proven difficult for owners/operators of collection systems since unlike potable water transmission mains; wastewater force mains generally lack redundancy. Additionally, visual inspection methods do not provide a full condition assessment of most pressure pipes since the loss of structural capacity is typically not visibly apparent. For example, while the presence of interior corrosion may visible within a concrete force main, the extent of the corrosion (e.g. loss of structural capacity) cannot be determined visually. Therefore, a true condition assessment and estimation of remaining useful life cannot be completed. Techniques or technologies allowing the force main to remain in service often allow for the most cost effective inspections by averting flow bypass. In order to develop a comprehensive strategy for force main assessment; technological, operational, engineering, and financial factors must be carefully evaluated to ensure resources are best implemented.

The proposed pipeline management approach provided herein not only provides a cost effective assessment of the structural integrity of each force main minimizing the risk of failure, it will also evaluate the financial implications of rehabilitation and/or replacement strategies. This can then be used to develop re-inspection schedules, prioritize rehabilitation and/or replacement, and develop long term management strategies. This approach will outline and subsequently detail the steps necessary for the development and implementation of a comprehensive force main condition assessment using techniques and technologies to provide LCPW with the necessary information for the long term management of force mains. One of the key philosophies of this approach is to focus valuable economic resources and personnel on condition data collection and evaluation, the most important aspect of a condition assessment and management program. The collection and evaluation of condition data should be the primary focus of any force main assessment as this is the only true measure of the pipeline's remaining useful life.

In order to effectively manage buried infrastructure, an understanding of the pipeline likelihood of failure (i.e. the pipe's condition) and consequence of failure must be understood to make knowledgeable decisions in the maintenance and extension of the asset's remaining useful life. Therefore, the goal of the management approach is to provide a cost effective inspection and assessment strategies to determine the existing condition of the force main, estimate the remaining useful life of the asset, and evaluate the Return on Investment (ROI) associated with various corrective actions (rehabilitation and/or replacement). Pure Technologies will ultimately deliver a safe, reliable and scientifically defensible pipeline management strategy for the PCCP Force Main that minimizes budget expenditures and personnel costs by focusing on the most important aspect of the project, inspection and evaluation. Pure Technologies' continuing investment in organic research and development ensures that our clients will always have access to leading-edge solutions combined with experienced, reliable technical support and expertise to assist in meeting the demands of increasing environmental and budgetary constraints. We are confident that Pure Technologies will deliver the most comprehensive and efficient force main condition assessment for LCPW.

It is important to note that there is no single technology or technique that provides a comprehensive assessment of a wastewater force main. Defects and deterioration of force mains

can be wide ranging and can vary from one pipe material to another. To identify different defects in wastewater force mains, it is often prudent to use multiple techniques and technologies. Too often, inspection techniques and assessment strategies are implemented without consideration of the particular force main characteristics and ultimate informational needs for the pipeline. By using this "broad brush approach" to force main assessment, valuable financial and operational resources are often depleted without providing the necessary information for managing the pipeline. Through Pure Technologies experience with pressure pipe assessment techniques and technologies, we will provide an individualized and effective assessment strategy for each force main while maintaining a high level of efficiency to maximize financial resources.

This Proposal has been prepared based on the record drawings and the submittal data provided by LCPW to Pure Technologies. This data indicates that the force mains are constructed of Prestressed Concrete Cylinder Pipe (PCCP).

Task I: Data Collection and Gap Analysis

Prior to the development of any pipeline management program, existing information as it relates to the program and/or specific assets will be collected and reviewed. As part of the review, existing information must be compared with what is necessary to develop an assessment prioritization and ultimately the condition assessment of each asset. This "gap analysis" will provide a summary of the available information related to the PCCP Force Main as well as what is not currently available. Information provided includes the diameter and length of the 30-inch PCCP force main. Additional pipeline specific attributes will be necessary to develop the comprehensive management strategy for the force mains. In particular, an understanding of pump station operation and pipeline hydraulics is necessary to develop the structural analysis models that assist in estimating remaining useful life of the force mains. It is critical to understand what information is necessary to provide an adequate condition assessment of the subject pipeline prior to undertaking a pressure pipe inspection as significant cost and effort can be expended without gaining the necessary information to manage the asset. It is not known if the force mains were installed with a corrosion resistant liner or exterior coating. Further discussion on the deterioration mechanisms for PCCP force mains will be provided in later sections.

Hydraulic Evaluation

Hydraulics and their relationship to pressure pipe condition and operation have historically been one of the least understood and analyzed aspects of force main management. Too often, hydraulic modeling of force mains focus on the capacity of the system as it relates to the utility's Capacity Management Operations and Maintenance (CMOM) program. While this is an important consideration in the management of the force main, pressure is also one of the primary data inputs when conducting a structural evaluation and subsequent remaining useful life estimation of a pressure pipeline. While most force mains operate well below the design capacity of the particular pipe material, when pipe wall degradation is combined with either the operational pressure and/or surge pressure, the likelihood of failure can be significantly increased. Therefore, one of the initial phases of any force main condition assessment and

management program should be the hydraulic evaluation of the pump station and force main systems and/ monitoring for short duration pressure transients.

The hydraulic evaluation of any pump station and pressure pipeline system is critical in developing a successful management strategy for a force main. Understanding the pump station operational characteristics such as pump start-up mode (e.g. on/off, variable frequency drives, etc.), typical and peak flows, operating and surge pressures, and surge protection provide important information on the stresses imparted on the force main. Therefore, quantification of these parameters is necessary for a structural evaluation of the force main to be completed. It should also be noted that if pumps are operating either below or above their specified best efficiency points, deterioration to the pump may occur or energy efficiency may be low. Therefore, assessing pump parameters for a force main assessment provides benefits in the actual operational efficiency of the pump station as well. The hydraulic evaluations of pump stations and force mains are also beneficial for pipelines that are low risk and may not warrant additional condition data collection as this information could be used for capacity assessments under the CMOM program and vacuum/pressure surge events within the force main could lead to premature failures.

A hydraulic evaluation of a pump station and force main system is completed in two phases: first, pressure transient modeling with the second as the modeling of the force main using existing pump station and pipeline data. Implementation of a pressure transient monitoring program determines the impact of various operational characteristics on the force main as well as to validate and/or calibrate the transient model. The occurrence of pressure transients within a force main can have adverse effects on the integrity of a pipe section as they can cause damage to the structural capacity of the pipe depending on the magnitude of the transient and current condition of the pipe. Accumulated damage of this nature can eventually decrease the structural integrity of the pipe. Pressure surges may also have significant effects on already weakened areas of the force main that have been deteriorated through internal or external corrosion. Therefore, it is important to understand the frequency and magnitude of pressure transients in a force main to ensure that operational protocols can be implemented to maintain the pressures below the specified design. An understanding of the actual pressure in a line will also permit knowledgeable decisions regarding future modifications to the line or facilities that affect the performance of the pipeline.

Traditional pressure monitors collect data in intervals of seconds while transients may occur in fractions of seconds. A transient pressure monitoring system addresses the sampling frequency issue by continuously monitoring pressure and while under normal operating conditions, only records data every few minutes (based on user defines the intervals). However, when a transient occurs in the pipeline, it is important that a high rate of sampling occur since transients may occur in fractions of seconds. Collection of the transient data is critical in the hydraulic evaluation of the force main and ultimately the condition assessment of the pipeline. The transient data will also be used to calibrate the hydraulic model previously discussed.

The second phase of a pump station and force main hydraulic modeling is surge modeling of the system. This will allow for provision of not only the operation pressure at a given location along the force main but also the surge or transient pressure at that point. While a transient analysis for

a pump station and force main system may have been conducted during the design of each system, these analyses typically do not provide the detailed information necessary for a thorough condition assessment. These transient pressures are critical in performing a comprehensive structural evaluation of the force main at that location in conjunction with the condition data. If either hydraulic or surge models have been previously developed for the PCCP Force Mains, these can be integrated into the condition assessment approach.

Hydraulic modeling is not been included in the scope or pricing for this project. Further discussion and any necessary recommendations for this task will be included in the final condition assessment report if requested by LCPW.

Task II: Pipe Wall Assessment

PCCP relies on high strength steel prestressing wire wrapped around the pipe under stress to provide its strength. Due to its vulnerability to corrosion, the wire is embedded in a mortar coating, which provides an alkaline environment (a very effective form of corrosion protection) inhibiting corrosion. Problems arise in PCCP when the mortar, and thus the alkaline environment, is compromised, leaving the wire susceptible to corrosion. When corrosion of the prestressing wire occurs, the wire eventually breaks reducing the strength of the pipe at that location. If corrosion continues, multiple wire breaks may occur in the same region and can significantly reduce the pipe's strength, eventually to the point of failure. Failure of PCCP is usually a sudden, catastrophic event with no warning.

Assessing the condition of a PCCP force main is a challenging task that is best performed using state-of-the-art non-destructive testing technologies combined with sound engineering science and judgment. The primary goal of an inspection is to provide an understanding of the condition of the structural component that provides the pipe's strength—the prestressing wire. An electromagnetic inspection using Pure Technologies' patented assessment tools provides a non-destructive method of evaluating the baseline condition of the prestressing wire by estimating the quantity and location of wire breaks for each pipe section. In addition to corrosion, a common failure mode of prestressing wire is due a change in the manufacturing process during the 1970s. This process led to the production of wire with increased tensile strength but also reduced the ductility of the steel and made the wire susceptible to hydrogen embrittlement. The combination of low ductility in the wire and susceptibility to hydrogen embrittlement creates a high probability of failure for PCCP of this vintage.

A common analogy to describe the physics of electromagnetic inspections is to view the prestressing wire as a coiled inductor. The electromagnetic assessment equipment consists of transmitter and receiver coils that use the prestressing wire as an inductor that can alter an induced field. The coils are aligned with the transmitting coil on one side of the pipe and the receiver coil on the other. The transmitting coil generates a magnetic field on the prestressing wire and the resulting field on the opposite side of the pipe is recorded with the receiver coil. The equipment is moved through the pipe to obtain a magnetic signature of each pipe section. If the prestressing wire, acting as an antenna, is intact, the receiver coil detects a signal with certain characteristics. When the end of a pipe section is reached, the polarity of the detected field reverses because the coiled inductor ends. However, if the inductor is broken (i.e. the

prestressing wire is broken), the signal is altered and a new pole reversal occurs part way through the pipe. These unexpected reversals delay the arrival of the signal at the receiver and can be quantified to estimate the number of wire breaks.

An electromagnetic inspection detects broken prestressing wire in PCCP mains providing an estimate of the number of broken wire wraps as well as the location of the wire break damage. This information is then used as a data input into the hydraulic and structural evaluation previously described allowing so the likelihood of failure can be determined.

Robotic Inspection

Pure Technologies proposes to deploy its multi-sensor robotic inspection platform outfitted with the electromagnetic PCCP assessment tool, SONAR, high quality Closed Circuit Television (CCTV), and laser profiling sensors in order to provide a comprehensive condition assessment of the force main. The robotic inspection equipment includes a tethered robotic vehicle with a modular design allowing for varying and numerous configuration options for inspection of small, medium, and large diameter pipe applications. The crawler system is a multiple stage vehicle allowing for articulation on a horizontal and vertical axis relative to each other. This configuration allows the crawler the ability to be introduced into challenging access points and to negotiate multiple bends in pipes. The robotic vehicle is powered by four independently operable mini-tracks (similar in style to a military tank). The powerful tracks have allowed the crawler to achieve inspection deployments of over 5,000 linear feet using a fiber optic tethering cable. The electromagnetic sensors provide data for the quantification/location prestressing wire breaks. SONAR is utilized to determine pipe diameter, roundness, volume of debris, and significant pipe defects. SONAR emits pulses of sound then detects echo characteristics of this pulse to determine the distance of an object from the SONAR head. Since the speed of sound in the wastewater can be assumed as constant, the time from the pulse emission from the SONAR head to its subsequent detection is used to calculate the distance of an object. This data is converted into image format providing a cross sectional view of a pipeline under the wastewater flow. Since the SONAR equipment conducts a full pipe diameter scan every 1.2 seconds, an accurate profile of the pipeline can be conducted. The CCTV camera is a pan tilt and zoom camera that captures high resolution video and images. The camera uses special diode designed for use in lower light environments. In addition to the camera lights, the robotic crawler is fitted with variable intensity quartz halogen and high intensity light emitting diode illumination. The result is fine control over the brightness and quality of lighting in all diameters and types of pipe. The high resolution video provides high quality imagery allowing for significantly improved CCTV quality over traditional equipment. The laser profiling system quantitatively collects data on pipe diameter, deformation, wall loss, and protrusions. A laser source projects a ring on the pipe wall while a video camera records the image of the ring as the crawler travels through the pipe. The laser will highlight deflections and physical anomalies in the pipe wall creating a frame-to-frame ring characterizing the pipe shape. The ring in the video signal is stripped out and processed to create a 3D rendering of the pipe with the capability to generate individual reports. Gas and temperature profiling can also be provided as necessary.

Pure Personnel have reviewed the access points to perform this inspection with LCPW personnel and have been requested to enter the force main through the discharge manhole at Station 20+16.

Due to the operational constraints of operating the unmanned robotic crawler within the force main, the anticipated deployment lengths for the inspection of the Lake County 30-inch South Interceptor Force Main may be limited from this access point.

It is planned that the robotic crawler will be inserted into the force main at the discharge manhole located at Station 20+16. The first potential obstacle that the crawler will encounter is the 90-degree turn at the intersection of Wilson Road and Larkin Lane, approximate STA 33+00. This represents a distance of 1,284 feet. Pure Technologies anticipates the crawler will reach this location but we cannot determine if the crawler will be able to negotiate the bend based on existing information. The next potential obstacle is located at the end of Larkin Lane in the easement east of the railroad tracks at Station 39+45. This represents an additional 645 feet. At this location there is a 20-percent incline along with a 45-degree turn. Pure Technologies cannot guarantee that the crawler will be able to traverse past this area due to the combination of friction on the robotic crawler's tether at the bends as well as the loss of traction due to the slime layer on the pipe wall. A second access point into the pipe from the pumping station would increase the likely hood that the entire section of pipe can be surveyed.

In order to traverse the largest possible length of force main, Pure Technologies suggests that Lake County attempt to clean with force main with a cleaning pig. This will accomplish two objectives:

1. It will allow the crawler to traverse longer distances due to the absence of grease and/or sediment
2. It will allow a better visual assessment of the pipe wall.

Pure Technologies understands that it may not be operationally feasible to pig the force main and will work diligently to complete the inspection to the maximum extent it can.

Calibration/Forensic Evaluation of Inspection Results

There are numerous design variables that can affect an electromagnetic signature of PCCP so in order to conduct the most thorough analysis of the electromagnetic inspection data, a project specific calibration is ideal (however, but not required). Calibration improves the reliability and accuracy of wire break estimates. Calibration requires destructive testing of at least one pipe section, which may not be feasible for some pipelines. Since calibration is used to evaluate the electromagnetic data and not to determine test settings, if a calibration prior to the inspection is not practical, a post inspection calibration can be performed. Post inspection calibration is often performed when excavating pipes to replace a damaged pipe section (as determined by the inspection) or if modifications are being made to the main (e.g. cutting in a valve or other appurtenance). If a project-specific calibration cannot be conducted, Pure Technologies will use its extensive database to develop calibration curves for the project. Electromagnetic inspections performed based on this type of data (i.e., no calibration) have proven to accurately identify distressed pipe sections and relative levels of damage, but the specific accuracy of predicting the quantity of wire break damage can be reduced.

It should also be pointed out that forensic investigation of excavated pipe sections following the inspection can also provide important calibration information and, in some cases, may be used in lieu of a calibration. Forensic evaluation involves excavating and exposing select pipe sections to ascertain the true condition of the pipe and determine the cause of deterioration. This is often done through visual inspection, sounding, material sampling, and pipe dissection. Pure Technologies has performed numerous forensic investigations for PCCP owners across North America.

Our staff is dedicated to provide the most reliable, comprehensive assessment services to our clients, but condition assessment is not an exact science. The results of the forensic evaluation can be used to confirm wire break estimation algorithms, the acoustic response from leaks, and confirm the recommendations put forth to manage the force main. In some cases, the assessment results may adjusted based on the forensic evaluation. This confirmation process is particularly useful to minimize the risk of investing resources to repair pipe that may actually be in good condition (false positives) or, even worse, not repair a pipe that should have been repaired (false negatives).

Internal Corrosion Evaluation

Since the majority of non-ferrous force main failures occur due to internal corrosion (27%) and structural deterioration (27%) based on the 2010 WERF Study *Inspection Guidelines for Wastewater Force Mains*), surveys to identify areas with the highest probability for these failure modes are critical. It is likely that failures due to structural deterioration of PCCP force mains are due to either internal corrosion of the concrete or prestressing wire failure (discussed in a later section). Gas pockets in force mains are of significant concern as concentrations of hydrogen sulfide gas within wastewater may be released from solution into the atmosphere and subsequently converted to sulfuric acid by bacteria in the slime layer on the pipe wall that may cause corrosion and eventual breakdown of the pipe's exposed surface. This is true for several pipe materials with the exception of non-corrosive (e.g. plastic) pipelines. It should be noted that traditional gravity sewer inspection techniques such as Closed Circuit Television (CCTV) and laser scanning/profiling may not adequately provide the actual magnitude of wall and structural capacity loss of concrete pipes. This is because through the deterioration process, the alkaline components of the concrete are converted to gypsum by the sulfuric acid. This reaction does not by itself decrease the actual physical diameter of the pipe however the gypsum has little to no structural capacity. Therefore, the concrete pipe may lose some if not all of its structural capacity without providing evidence as seen with CCTV and/or laser profiling/scanning. This deterioration process may also expose the reinforcing steel to corrosion. Gas pockets can also increase the significance of pressure transients within a force main since as the transient passes, vacuum conditions may be created. This may then cause cavitation at the gas pocket location increasing the stress on the pipe wall and thereby increasing the risk of failure if the structural capacity has been compromised. Pipeline leaks are of concern for all pipe materials as they emit illegal discharges to the environment and are often found to be the precursor of major failures. A pipeline failure can begin with weakening of the joint and/or barrel that may include a small leak. As constant use of the force main continues and potential pressure surges occur, the leak may grow, further weakening the pipe and possibly leading to an eventual failure. Therefore, identification of both gas pockets and/or leaks may eliminate these potential failures.

Identification of internal areas of a force main with potential corrosion is far more challenging however as traditional gravity pipeline inspection techniques are often not applicable to in-service pressurized pipelines. Acoustical based tools have been proven to identify and locate gas pockets and leaks along a pipeline by inserting a device capable recording changes in the background acoustical profile of the force main. These devices may be tethered or autonomous. In order to locate both gas pockets and/or leaks within the force main, Pure Technologies proposes the use of the SmartBall® acoustic sensor system that can reliably and accurately identify these anomalies. Pure Technologies also offers a tethered acoustic system, Sahara®, that can also provide accurate longitudinal and latitudinal above ground locations of the force main.

SmartBall is a platform for free-swimming inline surveys of large diameter water and wastewater pipelines best suited for long alignments with few connections and a suitable extraction location (i.e. pressure/gravity pipe transition, bar screens, etc.). Sahara is a platform for tethered inline surveys of large diameter water and wastewater pipelines that is most often used in wastewater force mains where an extraction location of the SmartBall tool is not available (i.e. inline pump stations). Surveys for both technologies are conducted under live operating conditions, providing condition information without any disruptions to service. Over 3,500 miles of pressure pipeline have been inspected with SmartBall and Sahara, with hundreds of leaks and gas pockets identified. Further, the SmartBall and Sahara technologies have successfully inspected more than 150 miles of wastewater force mains since 2009. Gas pockets identified by SmartBall or Sahara in wastewater force mains have been verified saving the pipeline owner significant costs by averting future failures and locating areas for rehabilitation/replacement.

An inspection of air release valves along each force main alignment is also recommended to identify (and repair) any valves that are not functioning properly. Fully operational air release valves are important in reducing the probability of gas pocket development at or near these high points.

Task III: Structural Modeling

While the screening techniques described above will provide data on potential areas of fore main deterioration, this information alone does not provide an indication of the condition of a pipe. The condition of PCCP should be ascertained through a direct assessment of the primary structural component of the pipe, the prestressing wire (discussed in subsequent sections). However, the presence of broken prestressing wires does not necessarily pose a significant threat to the pipeline. Low levels of wire break damage will increase the likelihood of failure, but in most cases, the increased risk is acceptable. The challenge associated with assessing and managing PCCP is determining how many broken prestressing wires creates an unacceptable level of risk thereby requiring repair and/or replacement actions. Pure Technologies has developed an innovative approach for condition based pipeline management using structural models along with hydraulic evaluation data ultimately delivering a comprehensive decision making tool for the management of a force main. For example, concrete strength in a PCCP force main may be reduced due to either hydrogen sulfide corrosion or broken prestressing wires, but this may not require the immediate rehabilitation or replacement of the pipe section allowing

the client to manage and/or monitor the deterioration focusing critical resources on higher risk areas of the collection system.

The primary intent of the structural analysis is to evaluate the associated risk of each PCCP section that has reduced structural capacity as a result of wire break damage. The prestressing wire is a principal structural component of PCCP and each individual class of PCCP installed in the subject pipelines was designed specifically for the maximum hydraulic operating pressure and soil covers expected along the route. Thus, any amount of wire break damage poses some level of risk to PCCP and should be carefully evaluated. Standard structural analysis of PCCP involves performing analyses based on AWWA C301 and C304, but these standards are intended for design of new pipe and do not provide a detailed prediction on the condition of a force main with broken prestressing wire wraps. To provide a better analysis tool, Pure Technologies has developed a three dimensional nonlinear finite element model that is used to predict the condition of a pipeline given known loading conditions and wire break damage from an electromagnetic inspection. The model is used to develop performance curves that are used to determine the predicted condition of a pipe section with wire break damage using limit states defined in AWWA C304. These limit states include:

- Microcracking - Microcracking (≤0.001-inch crack at 12-inches in length) of the mortar coating and/or concrete core. Microcracking of the mortar coating or concrete core may allow for corrosive elements (e.g. wastewater or ground water) to cause deterioration of the steel cylinder or more importantly, the prestressing wire.

- Visible Cracking – Visible cracking (≥0.002-inch crack at 12-inches in length) of the mortar coating and/or concrete core. Visible cracking further increases the probably of steel cylinder or prestressing wire corrosion and also indicates loss of compression of the concrete core.

- Yield - Cracked concrete core and/or mortar coating. Yielding of the steel cylinder and prestressing wire approaching the ultimate cylinder and wire stress. Once the steel cylinder and prestressing wire are at their yield limit, the material properties have reached plastic deformation and the ability to withstand internal and external stresses is reduced.

- Strength Limit - Cracked core and coating. Ultimate cylinder and wire stress. Pipe is in a state of incipient failure and while the pipe may not have ruptured, it should be considered no longer suitable for continued operation.

Task IV: Preliminary Results Letter

Through the condition assessment of each force main, data may indicate that several areas of the pipe are in a state of incipient failure. While the pipe has not ruptured, the asset cannot withstand the specified capacity either by the initial design or current operational parameters. It

may therefore fail catastrophically at any time if it is stressed by operational or environmental inputs. Therefore, these areas along a pipe are recommended for immediate repair.

Additionally, if a portion of the force main is taken out of service or exposed for external assessment and the results indicate moderate to significant distress, it is often recommended that remedial action be taken while the pipe is exposed. This may include repair of coatings or more significant structural repair or rehabilitation. The ability for the LCPW to act on the preliminary assessment data is critical in providing a cost effective repair/rehabilitation strategy. This is the logic behind conducting the structural modeling prior to performing the pipe wall assessment as it allows the LCPW and Pure Technologies to develop knowledge based rehabilitation/replacement decisions while the pipe is out of service or excavated for inspection. Immediate rehabilitation/replacement strategies should also be taken into consideration for moderately to significantly high risk pipes since large capital rehabilitation or replacement project may take years to implement increasing the probability of a failure.

Task V: Pipeline Managements Strategies and Reporting

By implementing the steps outlined above, an individual force main management strategy can be developed using technology and engineering judgment that provides a reliable long-term management plan for LCPW. This phase is one of the most critical in the project as developing a long term management strategy for a force main should deliver a safe, reliable, and defensible program for LCPW. Successful pipeline management programs are the result of a partnership between the utility and engineer so Pure Technologies' philosophy is to develop long term force main management strategies in close coordination with LCPW. When evaluating how to safely renew or extend the life of a force main, inspection data, structural assessment, and a comprehensive risk evaluation should be considered to make sound engineering recommendations. The risk evaluation considers not only the likelihood of failure (condition) of the force main based on the inspection data and structural modeling but also the consequence of a force main failure. In order to fully evaluate the risk associated with areas found to have damage based on the force main inspection, a risk matrix can be developed in order to provide a decision making tool for rehabilitation and/or replacement planning. Repair/replacement recommendations as well as long term management strategies can then be developed using the risk based assessment in order to provide a comprehensive force main management protocol. Risk tolerance is specific to LCPW so it is important to establish these criteria prior to the data evaluation process in order to establish an effective force main management strategy. It is also important to consider any asset management or strategic planning that the LCPW has undertaken so the assessment work conducted will fall within guidelines already established. Each force main should not be evaluated in a vacuum but recognize the management strategies of the collection system as a whole. This is critical when considering capital budget planning as well as operational and maintenance budget.

BUDGET

Pure Technologies strives to implement condition assessment programs to assess and address problems minimizing the expense associated with desktop studies and other office related aspects of a project. Our ability to quickly understand threats to force mains and develop assessment plans, allows us to focus a utility's budgets to the inspection and evaluation component of a condition assessment project—the component of most value to a utility.

Pure Technologies has a strong record of meeting schedules and budgets for force main condition assessment programs. This track record is attributed to significant planning in advance of the inspection and tracking expenses and progress during the execution of specific projects that are a part of a program. Pure Technologies will continue its practice of providing adequate planning and tracking of project expenses for the client and fully expects to be on or under budget for any force main condition assessment program. The fees provided below should be considered budgetary purposes only and may be further refined should additional information on the force main be provided.

Task	Fee
Task I: Kickoff Meetings, Data Collection/Evaluation, and Development of Transient Monitoring Program [1]	$ 9,000
Task II: Pipe Wall Assessment • **Robotic Electromagnetic Pipe Wall Evaluation** ○ **Hi-Definition CCTV and Sonar**[2] • **SmartBall Gas & Leak Detection Survey Inspection**	 $ 85,000 $ 40,000
Task III: Structural Modeling/Analysis[3]	$ 7,000
Task IV: Preliminary Results Letter	$ 10,000
Task V: Pipeline Managements Strategies & Reporting	$ 16,500
Total	$ 167,500

Notes:

1. Assumes Lake County staff will assist with installation/removal of pressure transient monitors.
2. Hi-Definition CCTV and Sonar will be provided as condition permit and as applicable.
3. Assumes one pipe design analysis per force main. More pipe designs may require additional analysis depending on the inspection results.

SCHEDULE AND DELIVERABLES

Below is detailed a proposed list of the deliverables and timelines for the scope.

Task I: Data Collection and Gap Analysis
A technical memorandum detailing defining the necessary and available information required to complete the assessment of the force mains will be submitted 15 calendar days after notice-to-proceed (NTP).

Hydraulic Evaluation
A technical memorandum containing the information collected and/or modeled as part of this task will be submitted 45 calendar days after NTP

Task II: Pipe Wall Assessment
Prior to the Pipe Wall Assessment Pure Technologies will conduct a site visit to review the access point being utilized to conduct the inspection. A preliminary project plan will be submitted 30 calendar days after this site visit. The project plan will contain recommendations for any modifications to the force mains to facilitate the inspections. A draft data report will be issued 6 weeks after the inspection is completed.

Internal Corrosion Survey
Prior to conducting the SmartBall survey of the force mains Pure Technologies will conduct a site visit to determine a plan of action. A detailed project plan will be submitted 15 calendar days after this site visit. 60 calendar days after the survey a draft data report will be issued detailing the location and size of leaks or pockets of trapped gas.

Task III: Structural Modeling

A technical memoranda describing the hydraulic data inputs from Task II, the structural assessment technique used, and subsequent results of the analysis. This memorandum will be delivered 30 calendar days after the preliminary results letter is issued.

Task IV: Preliminary Results Letter

Due to the dynamic and expedited nature of the rehabilitation/replacement decisions made under this Task, the proposed deliverable will be letter reports from Pure Technologies to LCPW defining the pipe(s) to be rehabilitated/replaced and justification of this recommendation.

Task V: Pipeline Management Strategies and Reporting

The primary deliverable under this task will be the comprehensive condition assessment and management report for the subject force main incorporating information from all of the previous tasks. While Pure Technologies has developed a standard template for these reports, the report outline will be customized using input from LCPW staff based on their particular needs. A draft of this report will be delivered 4 weeks after all data reports have been accepted by LCPW.